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BIAS AND VARIABILITY IN AGE DETERMINATION COMPARISONS FOR 5Z j,m COD (1991-94)

by

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Abstract

Coefficient of variation estimates, bias plots for the analysis of trends or shifts between past age assignments (1991-1994), and a re-analysis in 1995 are reported for Georges Bank cod. Published Can/USA otolith exchanges and annual precision tests were also analyzed in this manner. Comparison matrices and percent agreement are also reported.

The percent agreement for the re-analysis of 1991-1994 age assignments ranged between 69% and 74%, corresponding to coefficients of variation of 4.64% and 5.20%. Bias plots suggest that the age by age bias is low and with no apparent pattern, and that the 95% confidence interval increases with age.

The present results suggest that within year precision is good, but that there is a small and consistent tendency for the second age determination to be lower than the original age. There is no apparent age specific bias, except possibly with older ages that usually account for only a few fish.

The Canada/USA exchanges show good agreement and coefficient of variation ranges, with similar values for both the author's results and the former experienced Canadian age reader. Both Canadian age readers seem to have a within year bias, but this bias is random when all years are reviewed together.

Résumé

On rend compte ici des estimations de coefficients de variation et des courbes de biais destinées à l'analyse des tendances ou des décalages dans les déterminations des âges de la morue du banc Georges réalisées dans le passé (de 1991 à 1994) ainsi que d'une ré-analyse pour 1995. On analyse également les résultats publiés des échanges d'otolithes canado-américains et de la vérification annuelle de précision. Enfin, on présente des matrices de comparaison et le pourcentage de concordance.

Le pourcentage de concordance dans la ré-analyse des déterminations d'âge réalisées de 1991 à 1994 s'échelonnait entre 69 % et 74 %, ce qui correspond à des coefficients de variation de 4,64 % et de 5,20 %. D'après les courbes de biais, il apparaît que le biais âge par âge est faible et ne présente pas de tendance apparente, et que l'intervalle de précision de 95 % augmente avec l'âge.

Il ressort des résultats actuels que la précision au sein d'une même année est bonne, mais que la deuxième détermination de l'âge reflète une légère tendance constante à la baisse par rapport à l'âge original. Il ne semble pas y avoir de biais spécifique à certains âges, à l'exception peut-être des âges plus élevés, qui ne comprennent habituellement que quelques poissons.

Il ressort des échanges canado-américains que la concordance et les gammes de coefficients de variation sont bonnes, les valeurs étant similaires tant dans les résultats de l'auteur que ceux de l'ancien spécialiste canadien expérimenté dans la détermination de l'âge. Un biais au sein d'une même année semble présent dans les résultats des deux spécialistes canadiens, mais ce biais est aléatoire quand on considère l'ensemble des années.

Introduction

Protocol for age determinations at the Biological Station, St.Andrews, N.B. requires the completion of within-year, intra-ager comparisons, and otolith exchanges for transboundary stocks. As well, long term intra-ager comparisons are required in order to detect trends, shifts, and bias in ageing determinations. This report uses the statistical methods for analysis of bias and coefficient of variance (CV) described in Campana et al. (1995).

Ages for cod in unit areas 5Zj and 5Zm from research survey have been determined since 1986, and for commercial fishery samples since 1960. In 1991 a transition period occurred where the author assumed full ageing responsibility for this stock. Within-year precision tests have been done since 1991 and reported since 1993 (Hunt and Buzeta, 1994 and 1995). Results of Workshops and exchanges between Canada and USA age readers have been reported for 1986, and 1991-1994 (Neilson et al. 1991, Buzeta et al. 1992, Hunt and Buzeta 1993, 1994 and 1995, Van Eeckhaute and Buzeta 1994). Long term trends or shifts in age assignments for 5Zj,m cod had not been previously reported. Past age assignments (1991 to 94) and a second age assignment in 1995 are documented here. As documented in assessment and age workshop reports cited above, age comparisons displayed acceptable levels of percent agreement; that is levels equal to those previously obtained for this stock by other age readers. However, a bias was documented in the 1994 assessment report (Hunt and Buzeta 1995), where 76% of the Canada-USA disagreements, and 91% of the intra-reader disagreements were assigned as one year older.

Methods

For each year 1991-1994, a random subsample of one per 3cm grouping was selected from the commercial samples and re-analyzed for age determination. In all cases the initial ages were not available until the completion of the second reading. Otoliths recorded as unreadable (null) in either or both determinations were not included in the statistics.

CV estimates and bias plots were calculated for comparisons between past age assignments (1991 to 94) and a second age assignment in 1995, between published Canada/USA exchanges, and for within year age comparisons. Details of methods are described by Campana et al. (1995). Percent agreement matrices were also produced.

The bias in age assignments of one age reader commonly assigning ages higher or lower than the other was estimated as the average of the pairwise difference

$$\overline{x_i - x_j}$$

between the Canadian ($_i$) and USA ($_j$) ages. Drift with time in age determinations by the Canadian age reader were calculated in the same manner, where $_i$ and $_j$ are the first and subsequent age assignments for that otolith.

Results

Comparison matrices for random subsamples from 1991-94 are shown in Tables 1a-d. The agreement between the initial age determination and the subsequent assignment in 1995 for these years is 69%, 77%, 70%, and 74%, corresponding to coefficients of variation of 4.67, 4.75, 4.64 and 5.20%. Disagreements seem evenly distributed throughout the different ages. For all years except 1992 there is a small but consistent tendency for the most recent age determination to be lower than that of the original age. However the age bias plots indicate that the mean bias was low (Figures 1-4 and Table 2). Summary of CV, percent agreement and pairwise age differences are shown in Table 2 and bias plots are shown in Figures 1-4.

The two within-year precision tests reported in 1993 and 1994 reflected past agreement tests. The CV estimate and plot for 1994 are not available for comparison.

Results for the annual Canada/USA comparisons for the present Canadian age reader show an agreement and CV of 85% and 2.38 respectively (the 1992 CV is not available). While age-readers often commented edge type as a reason for the age disagreements, it was also common to see discrepancies in the number of annuli observed. For the former Canadian age reader the overall Can/USA agreement and CV is 85% and 2.31. The age bias plots and the values for the pairwise age differences do not indicate any appreciable bias in any of the comparisons (Figures 4a-c, 5a-c and Table 2).

Discussion and Recommendations

The present results suggest that there is a small bias between past age assignments and subsequent re-ageing of these by the current age reader and this should be monitored. There was no appreciable bias between the Canadian and USA age readers. The Canada/USA exchanges show good agreement and CV ranges that are well below those reported for Baltic cod (Anon. 1994). The agreement and precision of age determinations done by the USA and the author are similar to those obtained between the former Canadian age reader and the USA.

Since 1991, otolith studies and workshops have isolated different features that may be related to age determination disagreements. Settling checks (Pentilla and Dery 1988) and correct assignment of the first annulus were identified as an issue for 5Zj,m cod in 1991 (Neilson et al. 1991, Buzeta et al., 1992) and subsequently studied by Buzeta in 1992. It was concluded that cross sectional width of each of these features can be used for an objective classification. Another feature that often increases the difficulty in assigning ages has been described as a "double second annulus or split annulus," and has been discussed previously by the author in the 1992 and 1994 Ageing Workshop reports (Buzeta et al., 1992 and VanEeckhaute et al., 1994). Ongoing studies for proper identification of this feature will be reported by the author. Preliminary results suggest a similar approach of objective classification. Discussions on edge type classification for 5Zj,m cod have been reported in the above two workshop reports. The authors comment on the difficulty of a precise assignment of age in the sample months where the width of the edge type

is the deciding factor. Previous reports point to the change in birthdate convention to realign to the January convention adopted by USA labs, and to further work in the classification of 'Narrow' and 'Wide' edge types. Adoption of the USA convention of counting or not counting edge type according to the sample month (and not having to define the edge width) should be investigated as a possible method of increasing precision in the Canadian cod age determinations.

It is difficult to evaluate the direct correlation between an age bias and the final estimate of population size of the Georges Bank cod stock. For example, in construction of the catch at age, ages greater than nine are combined into a single age group. Therefore a bias in older ages would have little impact on the final results. However, ageing errors in the younger ages may underestimate recruitment and have a potential effect on abundance estimates (Bradford, 1991).

Acknowledgements

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References

Anon. 1994. Report of the Workshop on Baltic Cod Age Reading, Gdynia, Poland 6-10 June 1994. ICES, C.M. 1994/J:5.

Bradford,M.J. 1991. Effects of ageing errors on recruitment time series estimated from sequential population analysis. Can. J. Fish. Aquat. Sci. 48:555-558.

Buzeta,M-I. 1992. Use of backcalculations on NAFO Subdivision 5Ze cod otoliths for the correct assignment of settling checks and first annuli. CAFSAC Res. Doc. 92/47, 15p.

Buzeta,M-I, J.J.Hunt, L.VanEeckhaute and N.Munroe. 1992. Georges Bank Cod and Haddock Ageing Workshop. CAFSAC Res. Doc. 92/119. 34p.

Campana,S., C.Annand and J.McMillan. 1995. Graphical and Statistical Methods for Determining the Consistency of Age Determinations. Trans. Am. Fish. Soc. 124:131-138

Hunt,J.J. and M-I Buzeta. 1992. Status of the Atlantic cod stock on Georges Bank in unit areas 5Zj and 5Zm, 1978-91. 1992. CAFSAC Res. Doc. 92/48. 23p.

Hunt,J.J. and M-I Buzeta. 1993. Biological Update of Georges Bank cod in Unit Areas 5Zj,m for 1978-92. 1993. CAFSAC Res. Doc. 93/39. 20p.

Hunt,J.J. and M-I Buzeta. 1994. Biological Update of Georges Bank cod in Unit Areas 5Zj,m for 1978-93. 1994. CAFSAC Res. Doc. 94/30. 33p.

Hunt,J.J. and M-I Buzeta. 1995. Biological Update of Georges Bank cod in Unit Areas 5Zj,m for 1978-94. 1995. CAFSAC Res. Doc. 95/5. 37p.

Pentilla, J. and L.M.Dery (eds). 1988. Age determination Methods for Northwest Atlantic Species. NOAA Tech. Rep. NWFS-72. 135p.

Neilson,J.D, M-I Buzeta and J.J.Hunt. 1991. Comparison of catch at age matrices employed by Canada and the United States in assessments of stock status of Atlantic cod in 5Z.1991. CAFSAC Res. Doc. 91/51. 22p.

L.VanEeckhaute, M-I. Buzeta, N.Munroe and V.Silva. 1994. Georges Bank Cod and Haddock Ageing Exchange and Workshop. CAFSAC Res. Doc. 94/84. 20p.

Table 1a. Comparison matrix for the age assignments by the Canadian age reader for otoliths from the 1991 Canadian commercial fishery.

1991 age assignments (across), May 1995 age assignments (down)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	-	TOT
1	1																	1
2		15	1	1														17
3		1	4	4													1	10
4			1	15	2												1	19
5					7	3												10
6						10	3	1									2	16
7							4	3									1	8
8								4	2								3	9
9									1			1					1	3
10									1	3	1							5
11								1		1	3	1						6
12												1					1	2
13															1			1
14													1	1				2
15																		
16														1				1
-																		
TOT	1	16	6	20	9	13	7	9	4	4	4	3	1	2	1		10	110
Percent agreement excluding nulls																		69
Percent of second age assignments of higher value																		7
Percent of second age assignments of lower value																		24

Table 1b. Comparison matrix for the age assignments by the Canadian age reader for otoliths from the 1992 Canadian commercial fishery.

1992 age assignments (across), May 1995 age assignments (down)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	-	TOT
1	3																1	4
2	2	16	1															19
3		5	6	1													1	13
4				7	2												3	12
5					19	1											2	22
6					1	3												4
7					1	2	10	1									3	17
8								1	2								2	5
9									6								1	7
10							1											1
11										2	2							4
12												1						1
13																		
14																		
15																		
16																		
-												1					3	4
TOT	5	21	7	8	23	6	11	2	8	2	2	2					16	113
Percent agreement excluding nulls																		77.08
Percent of second age assignments of higher value																		14.58
Percent of second age assignments of lower value																		8.33

Table 1c. Comparison matrix for the age assignments by the Canadian age reader for otoliths from the 1993 Canadian commercial fishery

1993 age assignments (across), May 1995 age assignments (down)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	-	TOT
1	3																	3
2		13	2															15
3			20	5	1													26
4				8	4													12
5				1	6	2												11
6						9	1	1										11
7					1		9	3										13
8							2	6	2	1								11
9							1		1	1								3
10									2	1								4
11												1						1
12																		
13										1								1
14																		
15																		
16																		
-									1	1								2
TOT	3	13	22	14	12	11	13	10	6	5		1						113
Percent agreement excluding nulls																		70.37
Percent of second age assignments of higher value																		7.41
Percent of second age assignments of lower value																		22.22

Table 1d. Comparison matrix for the age assignments by the Canadian age reader for otoliths from the 1994 Canadian commercial fishery

1994 age assignments (across), May 1995 age assignments (down)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	-	TOT
1		2																2
2		10	3															13
3			7	2														9
4				12	2												1	15
5					11		1											12
6					1	4	1											6
7					1		3	4									1	9
8								3	1									4
9									4								2	6
10																		
11																		
12																		
13																		1
14																		
15																		
16																		
-																		
TOT		12	10	14	15	4	5	7	5		1						4	77
Percent agreement excluding nulls																		73.97
Percent of second age assignments of higher value																		4.11
Percent of second age assignments of lower value																		21.92

Table 2. Summary of precision tests and comparisons between age assignments. A positive bias for the yearly comparisons indicates the second age assignments were , on average, higher than the first. A positive bias for the Canada/USA exchanges indicates that the Canadian ages were, on average, higher than the USA ages.
[1]Bias here is represented by the average of the pairwise difference in age assignments.

Comparison test	N	% Agreement	CV	Bias[1]
1991-95	100	69	4.67	0.19
1992-95	96	77	4.75	-0.09
1993-95	111	70	4.64	0.14
1994-95	74	74	5.20	0.16
1993-93	116	79	2.88	0.20
1994-94	73	79	-	-
1991 Can/USA exchange	24	87	1.73	0
1992 Can/USA exchange	95	82	-	-
1993 Can/USA exchange	87	89	1.90	0.03
1994 Can/USA exchange	148	80	3.52	-0.12
1986 Former Can/USA exchange	123	73	3.57	0.29
1990 Former Can/USA exchange	109	92	2.00	-0.04
1991 Former Can/USA exchange	102	89	1.36	-0.03

Figure 1a.

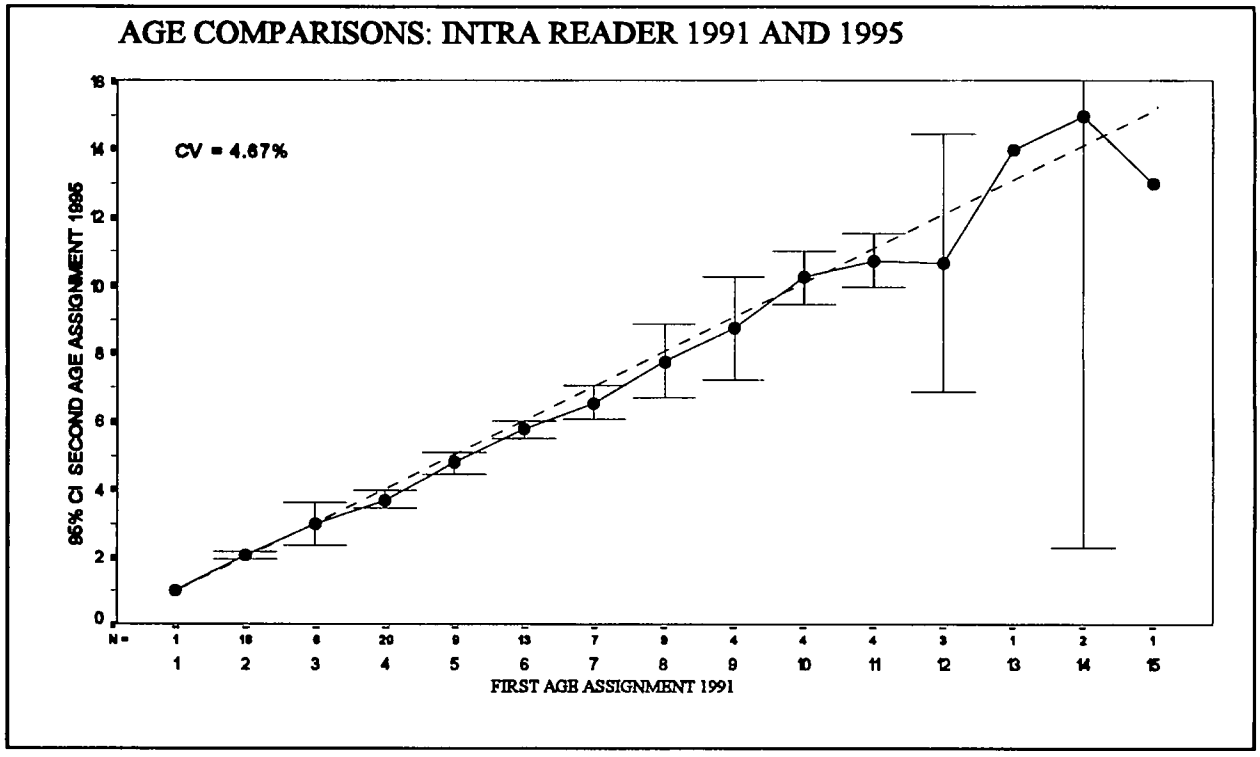


Figure 1b.

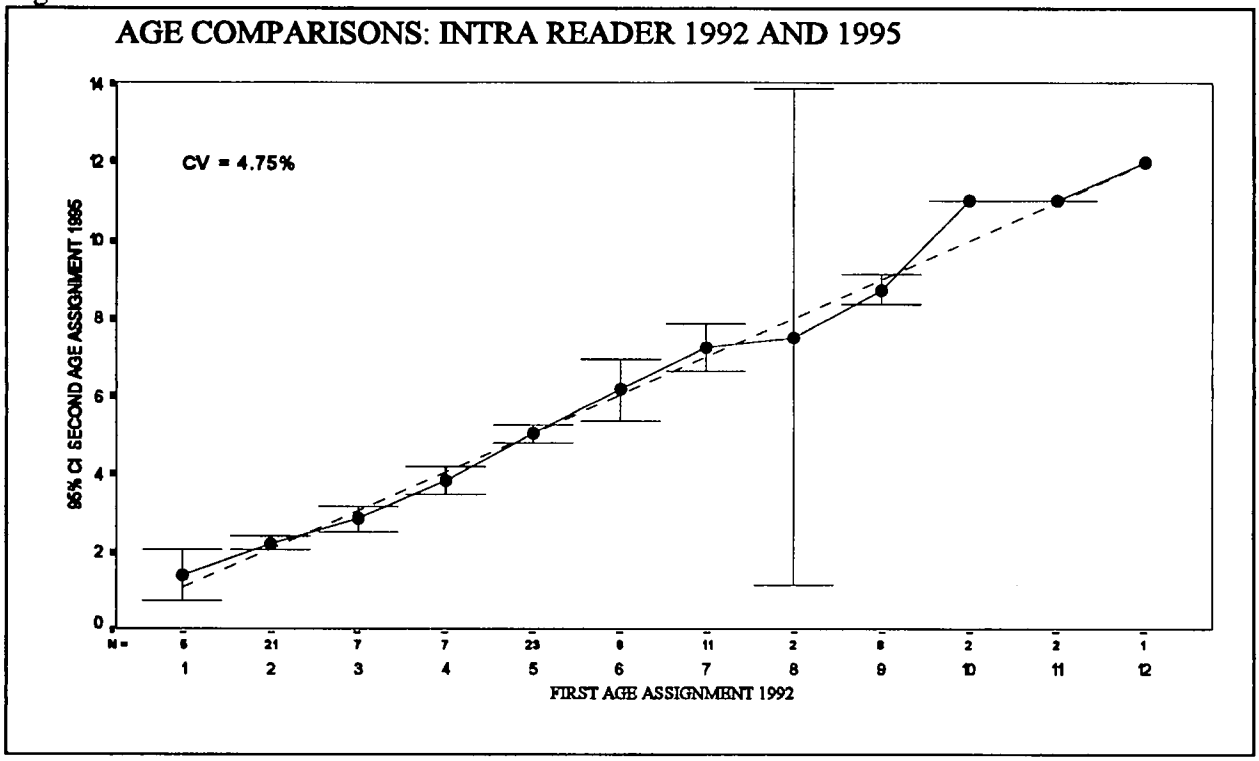


Figure 1c.

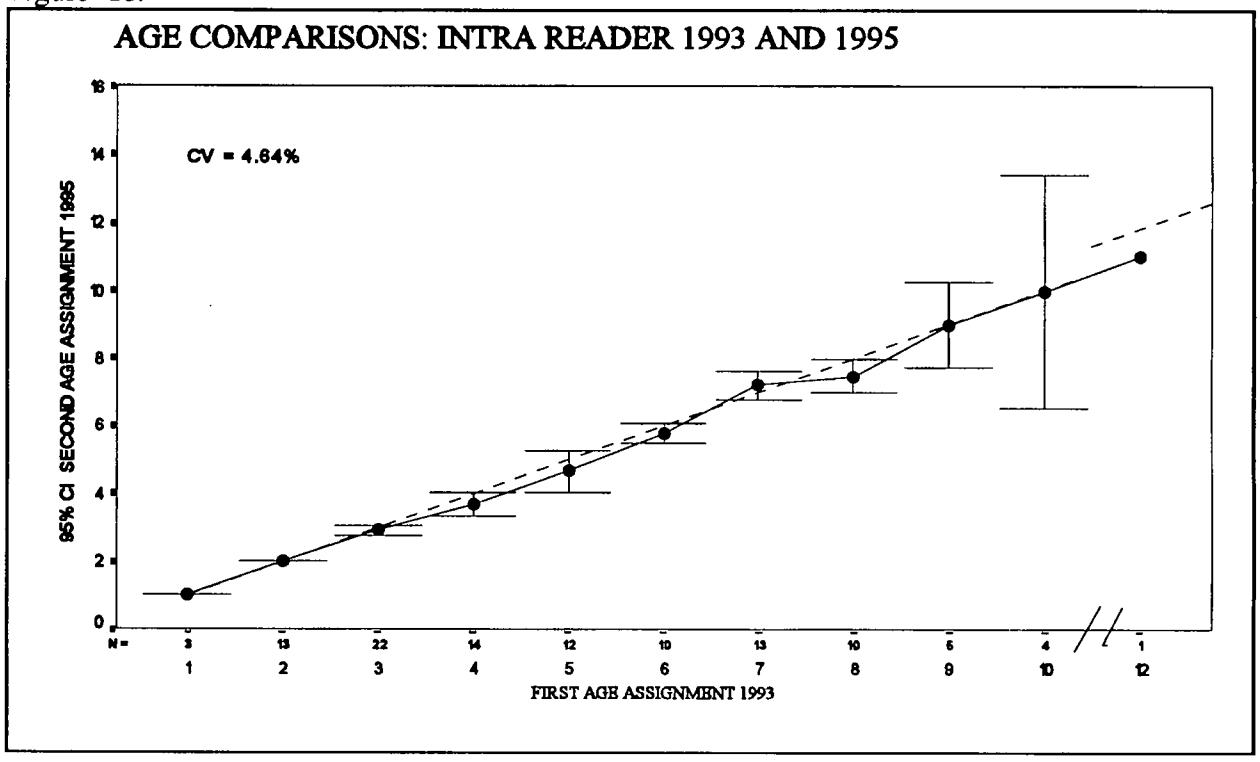


Figure 1d.

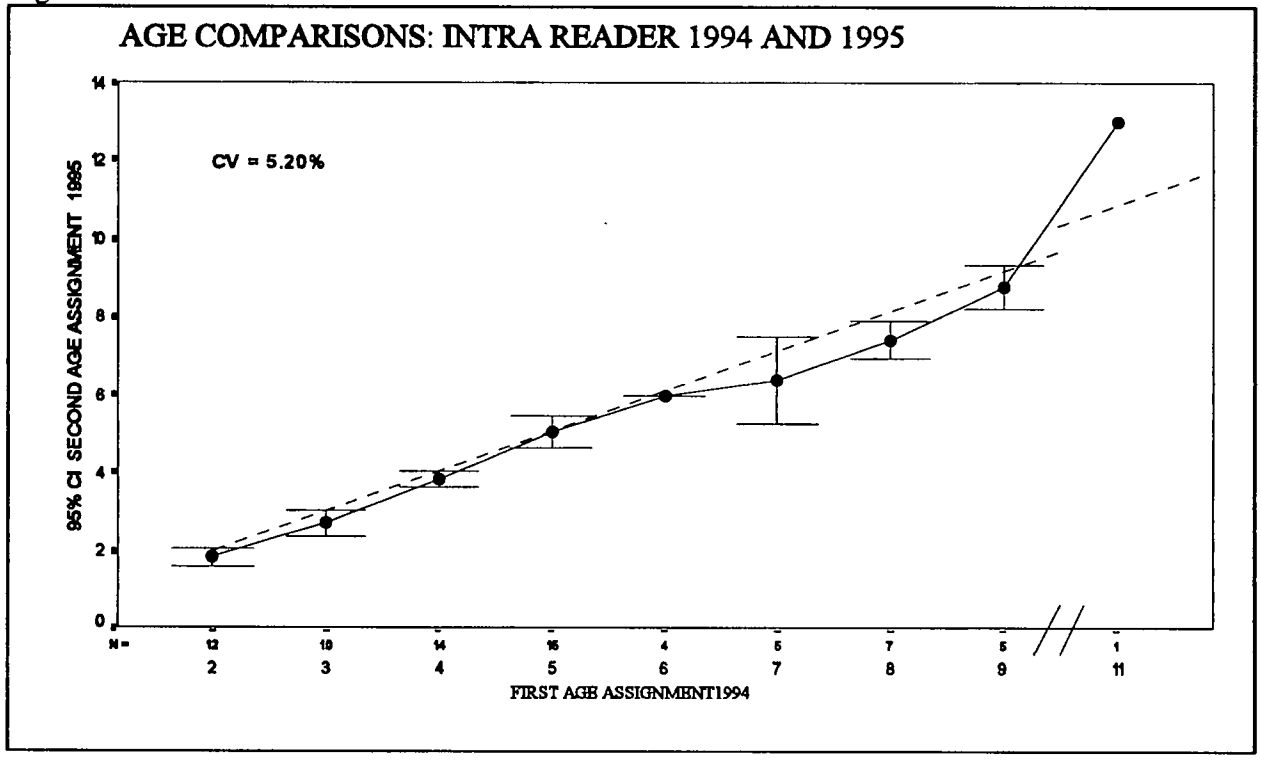


Figure 2.

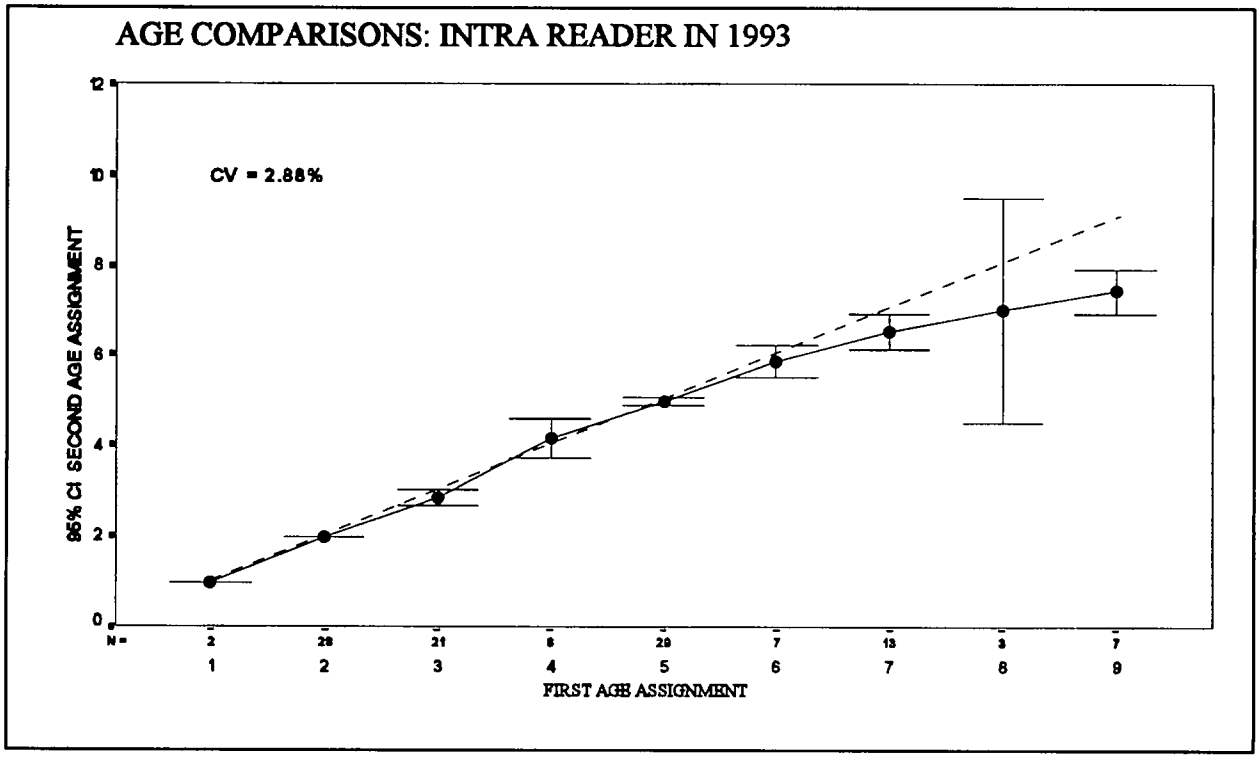


Figure 3a .

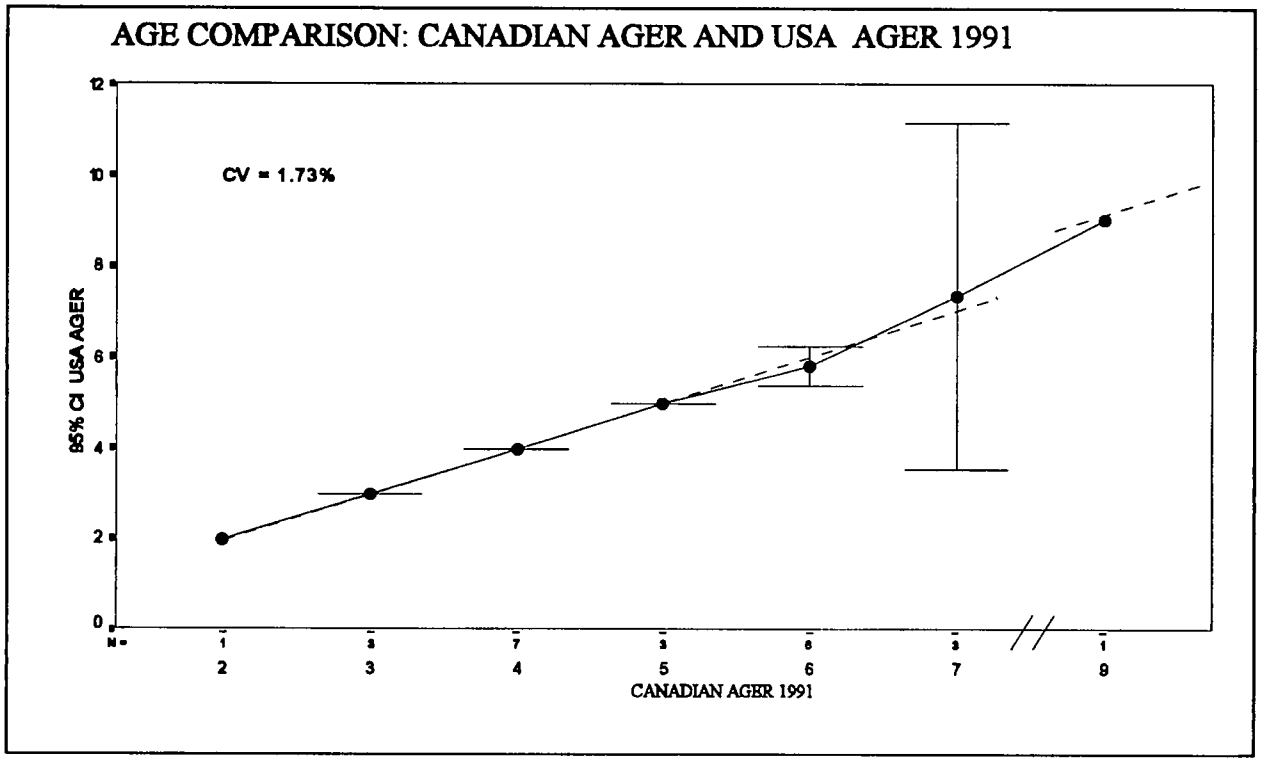


Figure 3b.

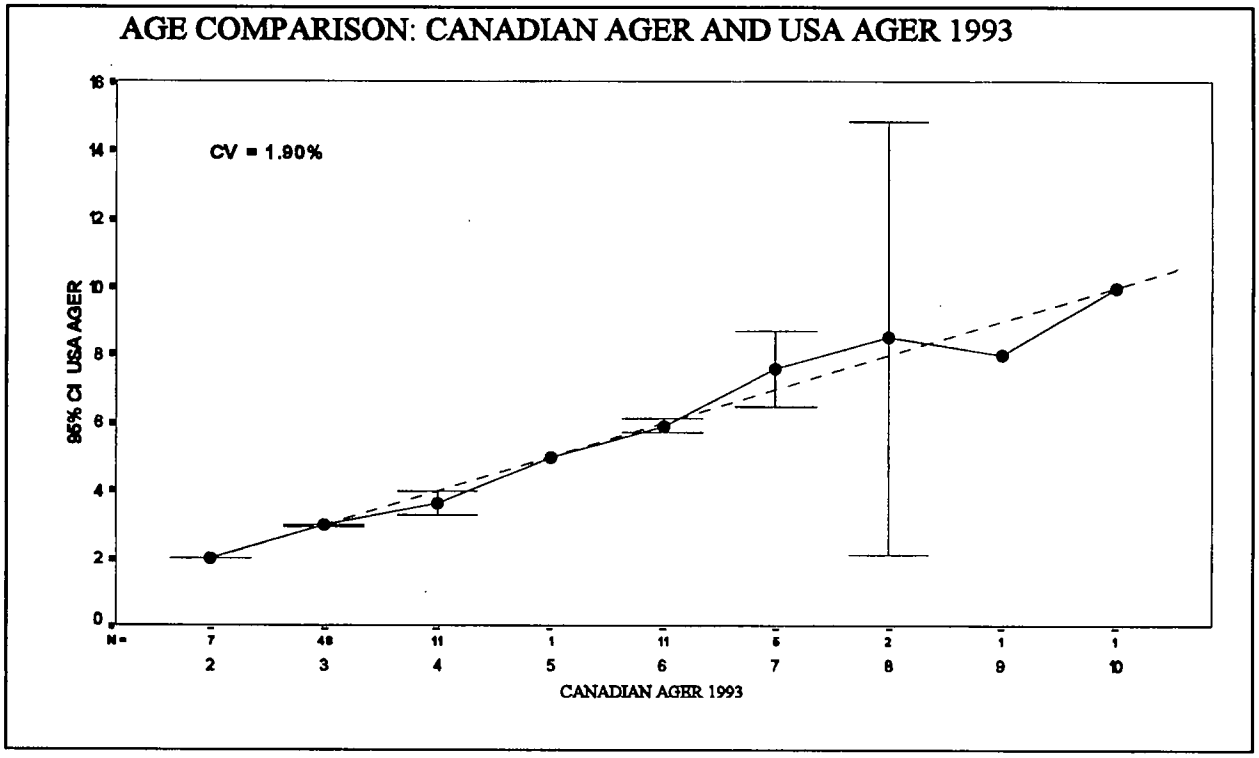


Figure 3c.

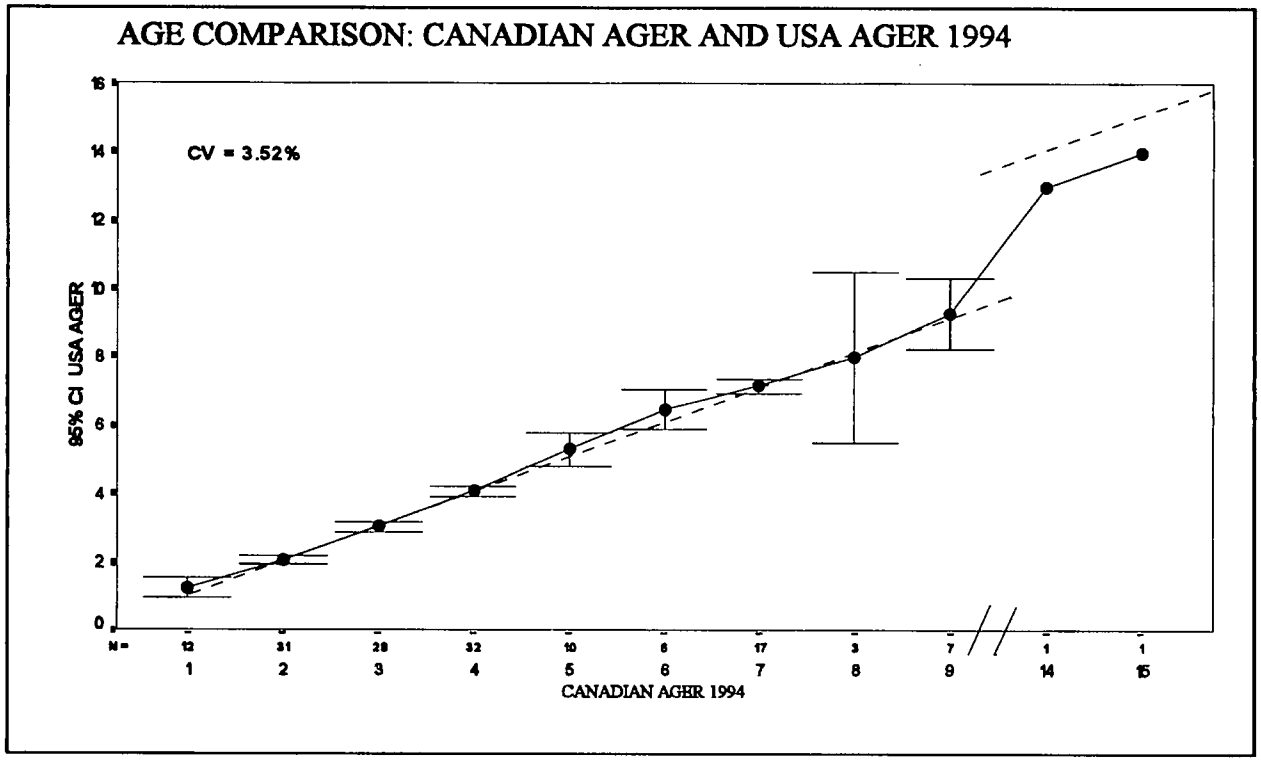


Figure 4a.

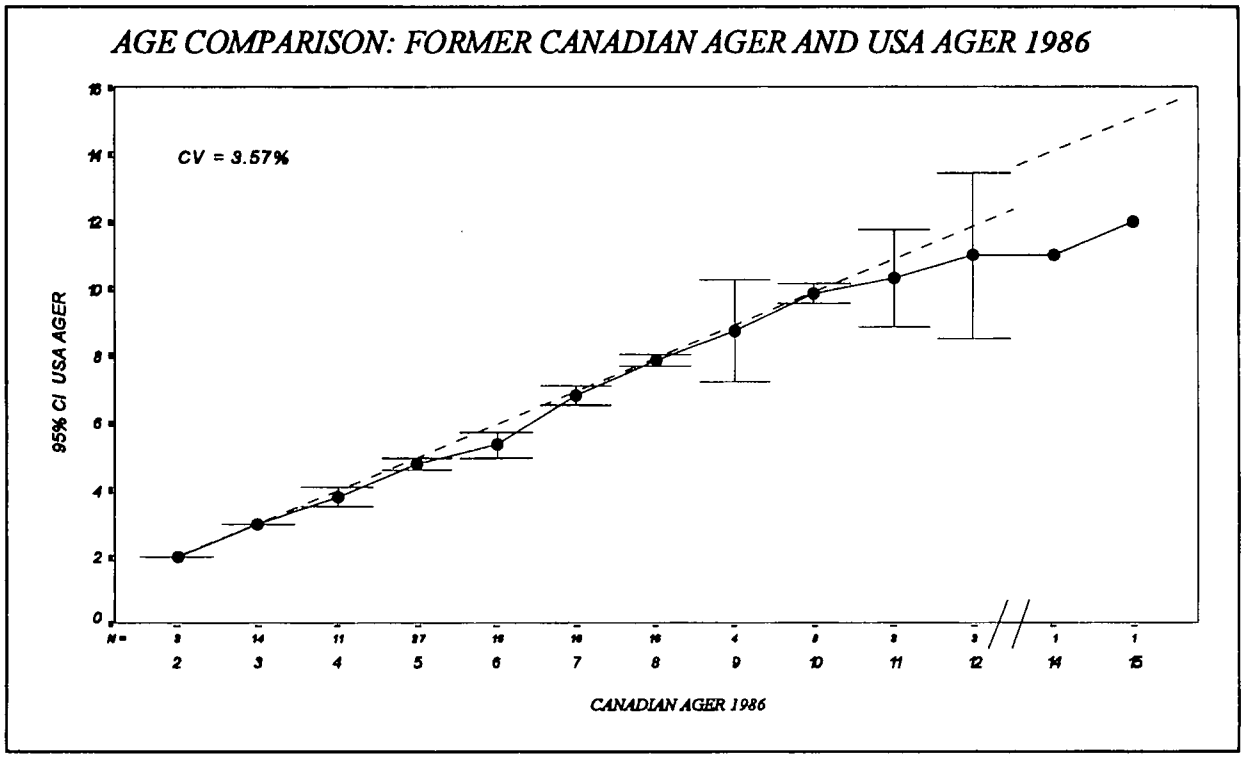


Figure 4b.

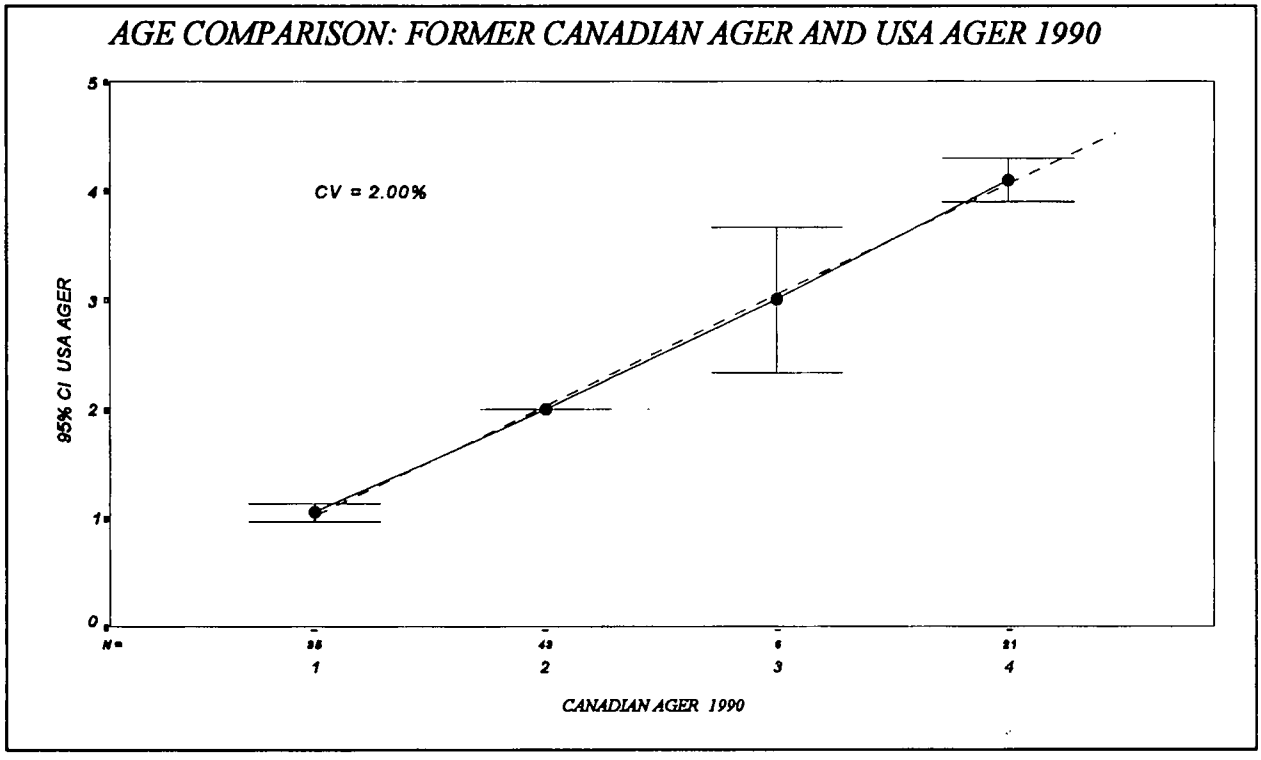
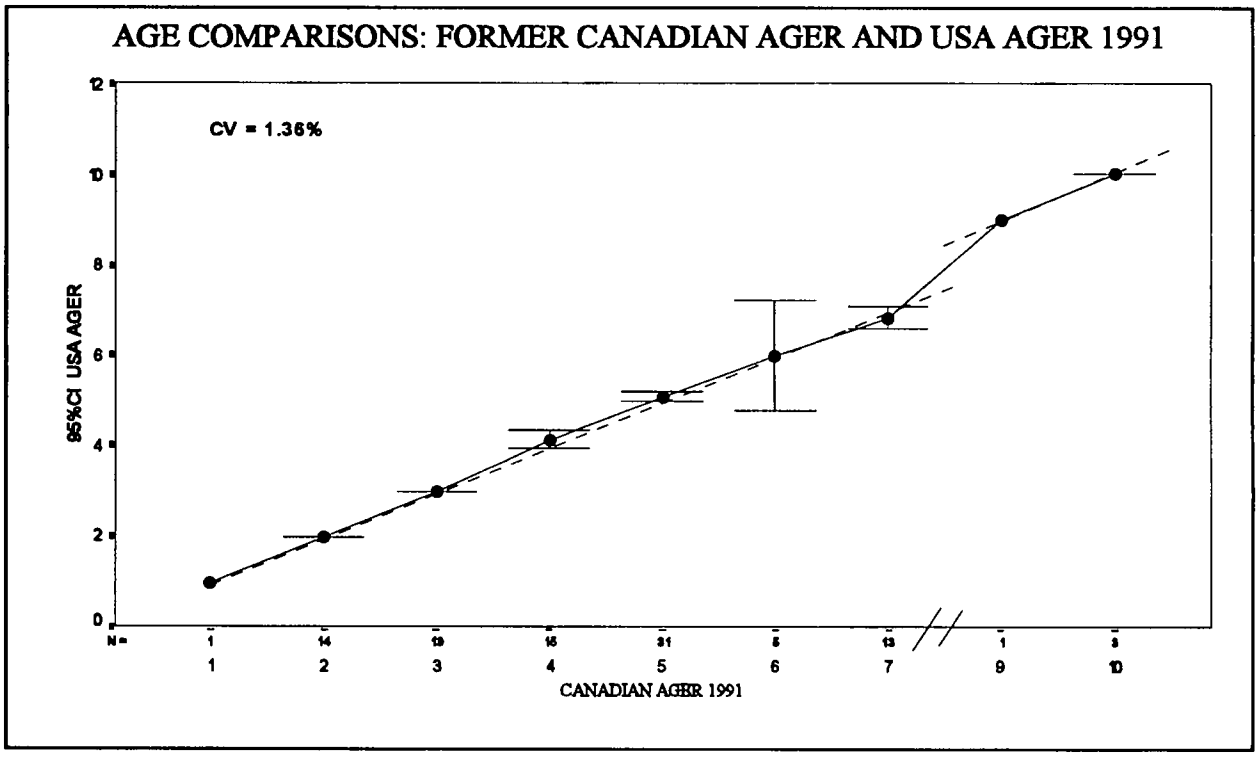


Figure 4c.


AGE COMPARISONS: FORMER CANADIAN AGER AND USA AGER 1991
CV = 1.36%
95%CI USA AGER
0
2
4
6
8
10
12
N=
1
14
19
16
31
6
13
1
3
1
2
3
4
5
6
7
9
10
CANADIAN AGER 1991